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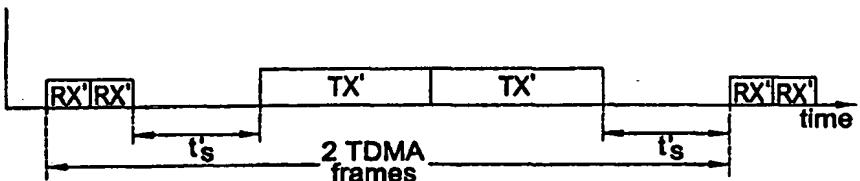
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(54) Title: TIME DIVISION MULTIPLE ACCESS (TDMA) METHODS WITH A COMMUNICATIONS CHANNEL INCLUDING TWO TIME SLOTS IN A COMMON FRAME AND RELATED TERMINALS AND SYSTEMS



(57) Abstract

A method for providing time division multiple access (TDMA) communications includes the step of defining a plurality of time division multiple access (TDMA) frames on a common carrier wherein each of the frames includes a respective plurality of time slots. A communications channel can be defined on the common carrier to include two time slots of a first one of the frames, no time slots of a second one of the frames, and two time slots of a third one of the frames wherein the first frame precedes the second frame and the second frame precedes the third frame. More particularly, the two time slots of the first frame can be consecutive time slots and the two time slots of the third frame can be consecutive time slots.

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WO 00/27053

PCT/US99/20731

TIME DIVISION MULTIPLE ACCESS (TDMA) METHODS WITH A COMMUNICATIONS CHANNEL INCLUDING TWO TIME SLOTS IN A COMMON FRAME AND RELATED TERMINALS AND SYSTEMS**Field of the Invention**

The present invention relates to the field of communications and more particularly to time division multiple access (TDMA) communications.

5

Background of the Invention

In a satellite radiotelephone communications system, such as the Asia Cellular Satellite (ACeS) System developed by Lockheed Martin and Ericsson Mobile Communications, radiotelephone communications are provided to one or more mobile radiotelephone user terminals through one or more satellites.

10 An ACeS satellite can be a geostationary satellite providing communications channels to a geographic region through one or more spot beams. Moreover, the AceS satellite can be coupled to a terrestrial controller providing links to other satellite communications systems, public switched telephone networks, and/or public mobile networks. Accordingly, an AceS radiotelephone user

15 terminal can communicate with other AceS radiotelephone user terminals, terrestrial based radiotelephone terminals, and/or public switched telephone terminals.

To increase the number of communications channels available within a limited bandwidth, the ACeS system uses time division multiple access (TDMA) techniques to provide a plurality of communications channels on each of the carrier frequencies used in the system. As will be understood by those having skill in the art, each carrier frequency is divided into TDMA time frames, and each TDMA time frame is divided into a plurality of TDMA time slots. Accordingly, a single time slot within a frame can be used to support a communications channel. Data compression techniques, for example, can be used to digitally sample speech at the radiotelephone terminal, compress the digital representation of the speech, and transmit the compressed digital

WO 00/27053

PCT/US99/20731

representation of the speech within the allotted time slot. Within a time frame, different time slots can be used to support communications with different radiotelephone terminals. On the receiving end, decompression techniques can be used to reproduce the speech with substantially imperceptible delay.

5 The ACeS system provides for communications at different data rates by assigning a time slot from each consecutive time frame to a communications channel for a full data rate channel (S-TCH/F); by assigning a time slot from every other time frame to a communications channel for a half data rate channel (S-TCH/H); by assigning a time slot from every fourth time frame to a communications channel for a quarter data rate channel (S-TCH/Q); or by assigning a time slot from every eighth time frame to a communications channel for an eighth data rate channel (S-TCH/E). Accordingly, a full data rate channel uses twice the capacity of a half data rate channel, and four times the capacity of a quarter data rate channel. More 10 particularly, a full data rate channel, according to the ACeS system, can provide a data rate of 9.6 kbits per second, a half data rate channel can provide a data rate of 4.8 kbits per second, and a quarter data rate channel can provide a data rate of 2.4 kbits per second. Moreover, voice communications can be provided on a half data rate channel.

15

20 The allocations of dedicated forward channels from the AceS satellite to the mobile radiotelephone terminals and dedicated return channels from the mobile terminals to the ACeS satellite according to the prior art are illustrated in Figures 1-5. A forward carrier **FC** (Figure 1) from the satellite to the mobile radiotelephone user terminals is a 200 KHz bandwidth carrier, 25 each associated return sub-carrier **RSC0** to **RSC3** (Figures 2-5) from the mobile user terminals to the satellite is a 50 KHz bandwidth carrier. There are four return carriers associated with each forward carrier. Moreover, each time frame for the forward carrier **FC** is divided into eight time slots **TF0** to **TF7**, and 26 time frames are grouped into each of the multiframe 4k, 4k+1, 4k+2, 30 4k+3, etc. As shown in Figures 2-5, each time frame for each of the return sub-carriers is divided into two time slots: **TR0** and **TR4** for return sub-carrier **RSC0**; **TR1** and **TR5** for return sub-carrier **RSC1**; **TR2** and **TR6** for return sub-carrier **RSC2**; and **TR3** and **TR7** for return sub-carrier **RSC3**.

WO 00/27053

PCT/US99/20731

The durations of the time frames in the forward and return directions are the same so that the duration of a time slot for a return sub-carrier is four times longer than a time slot for a forward carrier. Accordingly, each return sub-carrier has one quarter the bandwidth of the forward carrier, but the

5 duration of each time slot for a return sub-carrier is four times that of the duration of each time slot for the forward carrier. By allowing the mobile radiotelephone terminal to transmit over a longer period of time, the peak power required from the mobile user terminal can be reduced thus reducing battery drain, and easing power amplifier (PA) design.

10 Communications channels within the system are designated by the letters **A** to **H**, and the time slots within the illustrated frames supporting these channels are indicated by the letter in the time slot. As shown, channels **A** and **B** are full data rate channels, channels **C** and **D** are half data rate channels, channels **E** and **F** are quarter rate data channels, and channels **G** 15 and **H** are eighth data rate channels. The forward portion of full data rate channel **A** can be transmitted by the satellite using time slot **TF0** of the forward carrier **FC** during 25 of the 26 frames in a multiframe to provide the full data rate in the forward direction. The return portion of channel **A** can be transmitted by a mobile radiotelephone user terminal using time slot **TR5** of 20 the return sub-carrier **RSC1** during 25 of the 26 frames in a multiframe to provide the full data rate in the return direction. The time slots **TF0** and **TR5** in frame 25 which are not used by full data rate channel **A** can be left idle.

The forward portion of half data rate channel **C** can be transmitted by the satellite using time slot **TF2** of the forward carrier **FC** during 13 of the 26 25 time frames of a multiframe, and the return portion of the channel **C** can be transmitted by a mobile radiotelephone user terminal using time slot **TR7** of return sub-channel **RSC3** during 13 of the 26 time frames of a multiframe. The forward portion of quarter data rate channel **E** can be transmitted by the satellite using time slot **TF4** of the forward carrier **FC** during 6 or 7 of the 26 30 time frames of a multiframe, and the return portion of the channel **E** can be transmitted by a mobile radiotelephone user terminal using time slot **TR1** of return sub-carrier **RSC1** during 6 or 7 of the 26 time frames of a multiframe. The forward portion of eighth data rate channel **G** can be transmitted by the

WO 00/27053

PCT/US99/20731

satellite using time slot **TF6** of the forward carrier **FC** during 3 or 4 of the 26 time frames of a multiframe, and the return portion of the channel **G** can be transmitted by a mobile radiotelephone terminal using time slot **TR3** of return sub-carrier **RSC3** during 3 or 4 of the 26 time frames of a multiframe.

5 The intervals of transmission and reception over consecutive time frames for a mobile radiotelephone user terminal communicating over a full data rate channel (such as channel **A** or **B** as discussed above) is illustrated in Figure 6. The periods of transmission are designated **Tx**, and the periods of reception are designated **Rx**. As shown, for consecutive TDMA time
10 frames at the full data rate, the mobile terminal receives for approximately one eighth of the time frame and transmits for approximately one half of the time frame. Communications channels for the Asia Cellular Satellite (ACeS) System are discussed in the document entitled "Asia Cellular Satellite System SAIS: Multiplexing and Multiple Access on the Radio Path (SAIS 05.02)",
15 Lockheed Martin, January, 1998. The disclosure of this document is hereby incorporated herein in its entirety by reference.

Moreover, the mobile terminal preferably does not transmit and receive at the same time. By providing a system wherein the mobile terminal does not transmit and receive at the same time, the cost, size, and complexity of
20 the mobile terminal can be reduced. In particular, there is no need to provide a duplex-filter to isolate transmitted and received signals, and common synthesizers and oscillators can be used for both transmission and reception. When using common oscillators and synthesizers for transmission and
25 reception, however, a period of time may be required between transmissions and receptions at the mobile user terminal to allow settling of the synthesizers and oscillators.

In addition, time between transmissions and receptions at the mobile user terminal may be needed to accommodate delay spread between different mobile terminals using different time slots of the same return carrier. As will
30 be understood by those having skill in the art, mobile terminals at different distances from the satellite will have different signal delays, and synchronization may thus be needed to provide that signals from different mobile terminals using adjacent time slots of a common return carrier do not

WO 00/27053

PCT/US99/20731

arrive at the satellite at the same time. This problem is magnified in a satellite communications system as compared to a terrestrial cellular communications system because of the greatly increased geographic region over which a carrier can be received thus increasing the potential differences in signal

5 delays from different mobile terminals using different time slots of a common carrier. Timing advance can thus be used at the mobile terminal to provide that the mobile terminal does not transmit and receive at the same time, and to provide that the mobile terminal transmissions are not received at the satellite at the same time as other mobile terminal transmissions on different

10 time slots of the same carrier. In other words, the system can request that the user terminal adjust its transmit timing to fit timing alignment needs at the satellite.

Periods of time between transmission and reception at the mobile terminal may thus be needed to allow settling of the synthesizers and

15 oscillators, and to provide timing advance to accommodate differences in signal delays with respect to other mobile terminals. In the currently specified ACeS system, a time frame is approximately 4.62 msec long, a forward channel time slot is approximately 577 μ s long, and a return channel time slot is approximately 2.31 msec long. Accordingly, a mobile terminal

20 communicating on a full data rate channel according to Figures 1-6 receives transmissions for approximately 577 μ sec during consecutive frames and transmits for approximately 2.31 msec during consecutive frames, so that a total of approximately 1.73 msec are left per frame to accommodate synthesizer and oscillator settling as well as timing advance. In the best case,

25 this settling time t_s is evenly split before and after the transmission, as shown, so that approximately 865 μ s are provided before each period of transmission and reception.

This timing, however, may not be sufficient to reliably provide the necessary settling times and timing advance. It may thus be difficult to

30 provide full rate communications channels according to current ACeS system operations.

Summary of the Invention

WO 00/27053

PCT/US99/20731

It is therefore an object of the present invention to provide improved time division multiple access (TDMA) communications methods, systems, and terminals.

This and other objects are provided according to the present invention

- 5 by defining a plurality of time division multiple access (TDMA) frames on a common carrier wherein each of the frames includes a respective plurality of time slots, and defining a communications channel on the common carrier to include two time slots of a first one of the frames. The communications channel can further include no time slots of a second one of the frames, and
- 10 two time slots of a third one of the frames wherein the first frame precedes the second frame and the second frame precedes the third frame. More particularly, the two time slots of the first frame can be consecutive time slots and the two time slots of the third frame can be consecutive time slots. In other words, the communications channel can be provided using consecutive
- 15 TDMA time slots of alternating TDMA frames. Accordingly, increased time can be provided between transmission and reception at a user terminal allowing settling of oscillators and synthesizers used for both transmission and reception as well as allowing timing advance.

In addition, a second communications channel can be defined to

- 20 include only one time slot of at least one of the frames. The present invention can thus provide a first communications channel transmitted on two time slots per TDMA frame and a second communications channel transmitted on one time slot per TDMA frame. Accordingly, higher data rate channels can be provided consuming more capacity, and lower data rate channels can be
- 25 provided consuming less capacity. More particularly, the second communications channel can include only one time slot of every other frame, only one time slot of every fourth frame, or only one time slot of every eighth frame.

The common carrier can be transmitted by a base station to a plurality

- 30 of user terminals so that the communications channel defines a forward communications channel. In addition, a second plurality of time division multiple access (TDMA) frames can be defined on a second common carrier wherein each of the frames includes a second respective plurality of time

WO 00/27053

PCT/US99/20731

slots, and a return communications channel can be defined from one of the user terminals to the base station on the second carrier. This return communications channel can include two time slots of a first one of the frames of the second common carrier, no time slots of a second one of the frames of the second common carrier, and two time slots of a third one of the frames of the second common carrier wherein the first frame of the second common carrier precedes the second frame of the second common carrier and the second frame of the second common carrier precedes the third frame of the second common carrier.

10 Alternately, the common carrier can be transmitted by a user terminal to a base station so that the communications channel defines a return communications channel. In addition, a second plurality of time division multiple access (TDMA) frames can be defined on a second common carrier wherein each of the frames includes a second respective plurality of time slots, and a forward communications channel can be defined from the base station to the user terminal on the second common carrier. This forward communications channel can include two time slots of a first one of the frames of the second common carrier, no time slots of a second one of the frames of the second common carrier, and two time slots of a third one of the frames of the second common carrier wherein the first frame of the second common carrier precedes the second frame of the second common carrier and the second frame of the second common carrier precedes the third frame of the second common carrier.

20 Accordingly, improved time division multiple access (TDMA) methods, systems, and user terminals can be provided according to the present invention. In particular, by providing a TDMA communications channel on two time slots of a first time frame, no time slots of a second frame, and two time slots of a third frame, a relatively high data rate can be provided while maintaining adequate spacing between transmission and reception at the user terminal.

WO 00/27053

PCT/US99/20731

Brief Description of the Drawings

Figure 1 is a diagram illustrating an allocation of forward channels from a satellite to user radiotelephone terminals according to the prior art.

5 Figures 2-5 are diagrams illustrating allocations of return channels from user terminals to a satellite according to the prior art.

Figure 6 is a timing diagram illustrating periods of transmission and reception for a user terminal operating in a system with the full data rate channel allocations of Figures 1-5.

10 Figure 7 is a schematic diagram of a satellite radiotelephone communications system according to the present invention.

Figure 8 is a block diagram of a satellite user terminal for operation with the system of Figure 7.

Figure 9 is a diagram illustrating an allocation of forward channels from a satellite to user terminals according to the system of Figure 7.

15 Figures 10-13 are diagrams illustrating allocations of return channels from user terminals to a satellite according to the system of Figure 7.

Figure 14 is a timing diagram illustrating periods of transmission and reception for a user terminal operating in a satellite system with the full data rate channel allocations of Figures 9-13.

20

Detailed Description

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many 25 different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

As shown in Figure 7, a radiotelephone communications system 30 according to the present invention can be implemented as a satellite communications system including at least one satellite 21 and a terrestrial controller 23 which can be coupled to a wireless communications system such as a Public Land Mobile Network (PLMN) 26, and/or to a wired

WO 00/27053

PCT/US99/20731

communications system such as a Public Switched Telephone Network (PSTN) 25. The terrestrial controller 23 and the satellite 21 are coupled through radio links 27. The satellite 21 and at least one user terminal 29 can be coupled through radio links 31. More particularly, the radiotelephone 5 communications systems and methods of the present invention can be implemented in the ACeS satellite communications system developed by Lockheed Martin and Ericsson Mobile Communications.

As will be understood by those having skill in the art, the satellite 10 communications system can provide communications to and from a plurality of user terminals, and the satellite communications system can provide service through a plurality of spot beams (or cells) each covering a different geographic region. Moreover, the satellite communications system can include a plurality of satellites and/or a plurality of controllers. Accordingly, the satellite communications system can facilitate communications between 15 the user terminal 29 and another user terminal, or between the user terminal 29 and a telephone coupled to the public switched telephone network. The user terminal can be a radiotelephone, a portable computer, a personal digital assistant, or any other electronic device adapted for radiotelephone communications. In addition, the user terminal can be a battery powered 20 mobile user terminal.

In a satellite radiotelephone communications system according to the present invention, the communications system may establish a radiotelephone communications link with the user terminal 29 using a traffic channel via a radio link 31. For example, such a link can be initiated 25 responsive to a call placed by a telephone from the PSTN 25, the link can be initiated responsive to a call from another user terminal coupled to the satellite 21 or coupled to another satellite in the communications system, or the link can be initiated by the user terminal 29.

As shown in Figure 8, the user terminal 29 includes a transceiver 41 30 that transmits and receives communications to and from the satellite 21; a user interface 45 that accepts user input and provides user output; and a processor 43 that controls operations of the user terminal 29. More

WO 00/27053

PCT/US99/20731

particularly, the user interface can include a keypad 45A, a display 45B, a microphone 45C, and a speaker 45D.

The radiotelephone transceiver 41 preferably provides half duplex transmission and reception. In other words, the transceiver 41 does not

5 transmit and receive at the same time. With half duplex operation, there is no need for a duplex-filter to isolate transmission and reception at the user terminal. In addition, half duplex operation allows the use of common oscillators and synthesizers for both transmission and reception. Accordingly, the size, weight, complexity, and cost of the user terminal can be reduced.

10 With common oscillators and synthesizers used for transmission and reception, however, it may be useful to provide time between transmission and reception at the user terminal to allow the common oscillators and synthesizers to settle. Synthesizer settling times may be needed to allow a change of operating frequencies when switching between transmission and

15 reception. It may also be useful to allow time between transmission and reception to accommodate timing advance wherein user terminal transmissions are aligned with respect to other user terminal transmissions on the same carrier but different time slots so that the different transmissions on the same carrier do not reach the satellite at the same time.

20 The radio links 31 between the satellite 21 and the user terminal 29 can be provided using forward portions of communications channels from the satellite to the user terminal and return portions of communications channels from the user terminal to the satellite. The capacity of the system can be increased by providing time division multiple access (TDMA) forward and

25 return communications channels as discussed above in the Background of the Invention. Furthermore, different data rates can be provided between the user terminal and the satellite by providing full, half, quarter, and eighth data rate communications channels wherein full data rate channels provide the highest data rate at the expense of consuming the greatest capacity, and

30 wherein eighth data rate communications channels provide the lowest data rate while consuming the least capacity.

Allocations of time slots to the forward portions of full data rate communications channels A' and B', half data rate communications channels

WO 00/27053

PCT/US99/20731

C' and D', quarter data rate communications channels E' and F', and eighth data communications channels G' and H' are illustrated in Figure 9. Allocations of time slots to the return portions of full data rate communications channels A' and B', half data rate communications channels C' and D', quarter data rate communications channels E' and F', and eighth data communications channels G' and H' are illustrated in Figures 10-13. The allocation of forward and return channel time slots can be handled using submultiplex index (SMI) combinations allowing the satellite to align return communications without forcing the user terminal to simultaneously transmit and receive. Accordingly, time slots for forward and return channels can be assigned independently.

As shown in Figure 9, a plurality of forward communications channels can be provided on a forward carrier FC' having a bandwidth of 200 KHz. The forward carrier is divided into time frames of a predetermined duration, and each time frame is divided into eight time slots TRN0' to TRN7'. In particular, a time frame can have a duration of 4.62 msec, and a time slot can have a duration of 577 μ s. In addition, 26 time frames each can be grouped into multiframes 4k, 4k+1, 4k+2, and 4k+3. Accordingly, the time slots within a frame of the forward channel progress sequentially in time, the frames within a multiframe progress sequentially in time, and the multiframes progress sequentially in time. In other words, time slot TRN0' of frame 0 precedes time slot TRN1' of frame 0; frame 0 of multiframe 4k precedes frame 1 of multiframe 4K; and multiframe 4k precedes multiframe 4k+1. The forward communications channels provided on the forward carrier thus support transmissions from the satellite to one or more user terminals.

Return transmissions from user terminals to the satellite are provided on the return sub-carriers RSC0' to RSC3' as shown in Figures 10-13. Each of the return sub-carriers has a bandwidth of 50 KHz which is one quarter the bandwidth of the forward carrier. Moreover, each of the return sub-carriers is divided into time frames of the same duration used for the forward carrier, but each time frame of a return sub-carrier is only divided into two time slots. In addition, 26 frames for each return sub-carrier make up a multiframe.

Because one return sub-carrier provides only two time slots per frame, four

WO 00/27053

PCT/US99/20731

return subcarriers are used to provide a total of eight time slots per frame corresponding to the eight time slots in a frame of the single forward carrier.

In other words, four 50 KHz bandwidth return sub-carriers provide the same capacity as the single 200 KHz bandwidth forward carrier. Accordingly,

- 5 the satellite can transmit a predetermined number of bits on the 200 KHz bandwidth carrier during a $577 \mu\text{s}$ time slot, and a user terminal can transmit the same predetermined number of bits on a 50 KHz bandwidth carrier during a 2.31 msec time slot. This operation has the advantage that the user terminal can transmit the same amount of data over a longer period of time at
- 10 a lower peak power level thereby reducing battery drain and simplifying power amplifier (PA) design at the terminal.

The full data rate communications channels A' and B' can be provided, for example, in the forward direction on time slots TF0' and TF1' of the forward carrier FC as shown in Figure 9, and the full data rate communications channels A' and B' can be provided in the return direction, for example, on time slots TR1' and TR5' of the return sub-carrier RSC1', as shown in Figure 11. In particular, the forward portion of the full data rate communications channel A' can be transmitted by the satellite during the consecutive time slots TF0' and TF1' during even time frames, and the forward portion of the full data rate communications channel B' can be transmitted by the satellite during the consecutive time slots TF0' and TF1' during the odd frames. The return portion of the full data rate communications channel A' can be transmitted by the user terminal during consecutive time slots TR1' and TR5' during even time frames, and the return portion of the full data rate communications channel B' can be transmitted by the user terminal during consecutive time slots TR1' and TR5' of odd time frames. Time frame 24 or 25 can be left idle as shown in Figure 9.

The resulting periods of transmission Tx' and reception Rx' for the user terminal using a full data rate communications channel according to the present invention are illustrated in Figure 14. During a period of two TDMA time frames, the user terminal receives two consecutive time slots transmitted by the satellite and transmits two consecutive time slots to the satellite. The settling time t_s between transmission and reception at the user terminal can

WO 00/27053

PCT/US99/20731

thus be doubled thereby increasing the time allowed for settling of common synthesizers and oscillators used for both transmission and reception. This additional time also increases the time allowed for timing advance.

A radiotelephone communications system according to the present invention also supports half, quarter, and eighth data rate communications channels. The allocation of time slots for the half data rate communications channels C' and D' is illustrated in Figures 9, 10, and 13. For example, the forward portion of the half data rate channel C' is transmitted by the satellite during the time slot TF2' of even frames on the forward carrier FC', and the return portion of the half data rate channel C' is transmitted by the user terminal during time slot TR7' of even frames of the return sub-carrier RSC3'. Adequate time is thus provided for oscillator and synthesizer settling and timing advance during half data rate communications because, over a two TDMA time frame period, the user terminal receives during one forward time slot and transmits during one return time slot.

The allocation of time slots for the quarter data rate communications channels E' and F' is illustrated in Figures 9 and 12. For example, the forward portion of the quarter data rate channel E' is transmitted by the satellite during the time slot TF4' of time frames 0, 4, 8, 12, 16, 20 and 24 of multiframe 4K on the forward carrier FC', and the return portion of the quarter data rate channel E' is transmitted by the user terminal during time slot TR6' of time frames 0, 4, 8, 12, 16, 20, and 24 of multiframe 4K on the return sub-carrier RSC2'. Adequate time is thus provided for oscillator and synthesizer settling and timing advance during quarter data rate communications because, over a four TDMA time frame period, the user terminal receives during one forward time slot and transmits during one return time slot.

The allocation of time slots for the eighth data rate communications channels G' and H' is illustrated in Figures 9, 10, and 13. For example, the forward portion of the eighth data rate channel G' is transmitted by the satellite during the time slot TF6' of time frames 2, 10, and 18 of multiframe 4K on the forward carrier FC', and the return portion of the quarter data rate channel G' is transmitted by the user terminal during time slot TR3' of time frames 2, 10, and 18 of multiframe 4K on the return sub-carrier RSC3'.

WO 00/27053

PCT/US99/20731

Adequate time is thus provided for oscillator and synthesizer settling and timing advance during quarter data rate communications because over an eight TDMA time frame period, the user terminal receives during one forward time slot and transmits during one return time slot.

5 According to the present invention, a relatively high data rate communications channel can be provided for a user terminal by receiving during two consecutive forward time slots and transmitting during two consecutive return time slots over a two TDMA time frame period. Moreover, each of the transmissions during consecutive time slots can include

10 synchronization bits and/or error detection/correction bits as prescribed by conventional TDMA protocols. A communications system according to the present invention can thus support a first communications channel having a first data rate by defining the communications channel to include one time slot of every other time frame of a common carrier, and a second communications

15 channel having a second data rate two times the first data rate by defining the communications channel to include two time slots of every other time frame of the common carrier. More particularly, the two time slots in a frame can be consecutive time slots in the frame so that the user terminal transmits and receives for two consecutive time slots each during full data rate

20 communications.

During the full data rate communications according to the present invention, adequate time is thus provided between transmission and reception at the user terminal so that settling of common oscillators and synthesizers and timing advance can be provided. Moreover, TDMA communications according to the present invention have been discussed with regard to a satellite communications system with radio links between a satellite and ground based user terminals. TDMA communications according to the present invention, however, can also be used in terrestrial based communications systems such as terrestrial cellular radiotelephone communications systems. Accordingly, the term base station as used herein can include a satellite of a satellite communications system, a satellite of a satellite communications system together with a ground controller of the communication system, a base station for a terrestrial communication system,

WO 00/27053

PCT/US99/20731

and/or a base station for a terrestrial communications system together with a switching controller such as a mobile telephone switching office (MTSO).

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are 5 employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

WO 00/27053

PCT/US99/20731

THAT WHICH IS CLAIMED IS:

1. A method for providing time division multiple access (TDMA) communications, the method comprising the steps of:
 - defining a plurality of time division multiple access (TDMA) frames on a common carrier wherein each of the frames includes a respective plurality of time slots; and
 - defining a communications channel on the common carrier to include two time slots of one of the time division multiple access (TDMA) frames of the common carrier.
2. A method according to Claim 1 wherein the communications channel further includes no time slots of a second one of the frames, and two time slots of a third one of the frames wherein the first frame precedes the second frame and the second frame precedes the third frame.
3. A method according to Claim 1 wherein the two time slots of the first frame are consecutive time slots.
4. A method according to Claim 1 further comprising the step of:
 - defining a second communications channel to include only one time slot of at least one of the frames.
5. A method according to Claim 1 wherein each of the frames has a first common time duration and wherein each of the time slots has a second common time duration less than the first common time duration.
6. A method according to Claim 1 wherein the common carrier is transmitted by a base station to a plurality of user terminals so that the communications channel defines a forward communications channel.
7. A method according to Claim 6 further comprising the steps of:

WO 00/27053

PCT/US99/20731

defining a second plurality of time division multiple access (TDMA) frames on a second common carrier wherein each of the frames includes a second respective plurality of time slots; and

5 defining a return communications channel from one of the user terminals to the base station on the second common carrier to include two time slots of one of the frames of the second common carrier.

8. A method according to Claim 7 wherein the two time slots of the frame of the first common carrier of the forward communications channel are offset in time with respect to the two time slots of the frame of the second common of the return communications channel.

9. A method according to Claim 1 wherein the common carrier is transmitted by a user terminal to a base station so that the communications channel defines a return communications channel.

10. A method according to Claim 9 further comprising the steps of:
defining a second plurality of time division multiple access (TDMA) frames on a second common carrier wherein each of the frames includes a second respective plurality of time slots; and

5 defining a forward communications channel from the base station to the user terminal on the second common carrier to include two time slots of one of the frames of the second common carrier.

11. A method according to Claim 10 wherein the two time slots of the frame of the first common of the forward communications channel are offset in time with respect to the two time slots of the first frame of the second common carrier of the return communications channel.

12. A time division multiple access (TDMA) user terminal comprising:
a user interface that accepts user inputs;
a transceiver that transmits and receives radio communications to and from a base station; and

WO 00/27053

PCT/US99/20731

5 a processor coupled to the user interface and the transceiver wherein the processor defines a plurality of time division multiple access (TDMA) frames on a common carrier wherein each of the time division multiple access (TDMA) frames includes a respective plurality of time slots, and wherein the processor defines a communications channel on the common carrier to

10 include two time slots of one of the time division multiple access (TDMA) frames.

13. A user terminal according to Claim 12 wherein the processor further defines the communications channel to include no time slots of a second one of the frames, and two time slots of a third one of the frames wherein the first frame precedes the second frame and the second frame

5 precedes the third frame.

14. A user terminal according to Claim 12 wherein the two time slots of the first frame are consecutive time slots.

15. A user terminal according to Claim 12 wherein the processor defines a second communications channel including only one time slot of at least one of the frames.

16. A user terminal according to Claim 12 wherein each of the frames has a first common time duration and wherein each of the time slots has a second common time duration less than the first common duration.

17. A user terminal according to Claim 12 wherein the transceiver receives the communications channel from the base station so that the communications channel defines a forward communications channel.

18. A user terminal according to Claim 17 wherein the processor defines a second plurality of time division multiple access (TDMA) frames on a second common carrier wherein each of the frames includes a second respective plurality of time slots, wherein the processor defines a return

WO 00/27053

PCT/US99/20731

5 communications channel from the user terminal to the base station on the second common carrier to include two time slots of a first one of the frames of the second common carrier, and wherein the transceiver transmits the return communications channel to the base station.

19. A user terminal according to Claim 18 wherein the two time slots of the frame of the first common carrier of the forward communications channel are offset in time with respect to the two time slots of the frame of the second common carrier of the return communications channel.

20. A user terminal according to Claim 12 wherein the transceiver transmits the common carrier is to a base station so that the communications channel defines a return communications channel.

21. A user terminal according to Claim 20 wherein the processor defines a second plurality of time division multiple access (TDMA) frames on a second common carrier wherein each of the frames includes a second respective plurality of time slots, wherein the processor defines a forward 5 communications channel from the base station to the user terminal on the second common carrier to include two time slots of one of the frames of the second common carrier, and wherein the receiver receives the forward communications channel.

22. A user terminal according to Claim 21 wherein the two time slots of the frame of the first common carrier of the forward communications channel are offset in time with respect to the two time slots of the frame of the second common carrier of the return communications channel.

23. A time division multiple access (TDMA) communications system comprising:

5 a base station providing communications with a plurality of user terminals wherein the base station defines a plurality of time division multiple access (TDMA) frames on a common carrier wherein each of the time division

WO 00/27053

PCT/US99/20731

multiple access (TDMA) frames includes a respective plurality of time slots, and wherein the base station defines a communications channel on the common carrier to include two time slots of a first one of the time division multiple access (TDMA) frames.

24. A time division multiple access (TDMA) communications system according to Claim 23 wherein the base station further defines the communications channel to include no time slots of a second one of the frames, and two time slots of a third one of the frames wherein the first frame 5 precedes the second frame and the second frame precedes the third frame.

25. A time division multiple access (TDMA) communications system according to Claim 23 wherein the base station comprises a satellite base station, the system further comprising:

a terrestrial controller wirelessly coupled with the satellite base station 5 wherein the terrestrial controller provides a communications link with at least one of a wired terrestrial communications system and a wireless terrestrial communications system.

26. A time division multiple access (TDMA) communications system according to Claim 23 wherein the two time slots of the first frame are consecutive time slots.

27. A time division multiple access (TDMA) communications system according to Claim 23 wherein the base station defines a second communications channel to including only one time slot of at least one of the frames of the common carrier.

28. A time division multiple access (TDMA) communications system according to Claim 23 wherein each of the frames has a first common time duration and wherein each of the time slots has a second common time duration less than the first common duration.

WO 00/27053

PCT/US99/20731

29. A time division multiple access (TDMA) communications system according to Claim 23 further comprising:

5 a transmitter coupled to the base station wherein the transmitter transmits the communications channel to the user terminal so that the communications channel defines a forward communications channel.

30. A time division multiple access (TDMA) communications system according to Claim 29 wherein the base station defines a second plurality of time division multiple access (TDMA) frames on a second common carrier wherein each of the frames includes a second respective plurality of time 5 slots, and wherein the base station defines a return communications channel from the user terminal to the base station on the second common carrier to include two time slots of one of the frames of the second common carrier, the system further comprising a receiver coupled to the base station wherein the receiver receives the return communications channel from the user terminal.

31. A time division multiple access (TDMA) communications system according to Claim 30 wherein the two time slots of the frame of the first common carrier of the forward communications channel are offset in time with respect to the two time slots of the frame of the second common carrier of the 5 return communications channel.

32. A time division multiple access (TDMA) communications system according to Claim 23 further comprising:

5 a receiver coupled to the base station wherein the receiver receives the communications channel from the user terminal so that the communications channel defines a return communications channel.

33. A time division multiple access (TDMA) communications system according to Claim 32 wherein the base station defines a second plurality of time division multiple access (TDMA) frames on a second common carrier wherein each of the frames includes a second respective plurality of time 5 slots, and wherein the base station defines a forward communications

WO 00/27053

PCT/US99/20731

channel from the base station to the user terminal on the second common carrier to include two time slots of one of the frames of the second common carrier, said system further comprising a transmitter coupled the base station wherein the transmitter transmits the forward communications channel to the

10 user terminal.

34. A time division multiple access (TDMA) communications system according to Claim 33 wherein the two time slots of the frame of the first common carrier of the forward communications channel are offset in time with respect to the two time slots of the frame of the second common carrier of the 5 return communications channel.

WO 00/27053

PCT/US99/20731

1/12

FC (FORWARD CARRIER - 100 KHz Carrier)

Multiframe		4k																									
Frame	TF0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
TF1	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
TF2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6	G																										
TF7		H																									H
Multiframe		4k+1																									
Frame	TF0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
TF1	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
TF2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6	G																										G
TF7		H																									H
Multiframe		4k+2																									
Frame	TF0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
TF1	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
TF2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6	G																										G
TF7		H																									H
Multiframe		4k+3																									
Frame	TF0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
TF1	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
TF2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6	G																										G
TF7		H																									H

FIG. 1. (PRIOR ART)

WO 00/27053

PCT/US99/20731

2/12

RSCO (RETURN SUB - Carrier #0 First 50 KHz Carrier)

Multiframe Frame		4k																									
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
					H						H											H					
<hr/>																											
Multiframe Frame		4k+1																									
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
					H						H												H				
<hr/>																											
Multiframe Frame		4k+2																									
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
					H						H												H				
<hr/>																											
Multiframe Frame		4k+3																									
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
					H						H												H	H			

FIG. 2.
(PRIOR ART)

WO 00/27053

PCT/US99/20731

3/12

RSC1 (RETURN SUB - Carrier #1-Second 50 KHz Carrier)

Multiframe		4k																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1		E		E		E		E		E		E		E		E		E		E		E		E		E	
TR5		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Multiframe		4k+1																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1		E		E		E		E		E		E		E		E		E		E		E		E		E	
TR5		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Multiframe		4k+2																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1		E		E		E		E		E		E		E		E		E		E		E		E		E	
TR5		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Multiframe		4k+3																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1		E		E		E		E		E		E		E		E		E		E		E		E		E	
TR5		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	

FIG. 3.

(PRIOR ART)

WO 00/27053

PCT/US99/20731

4/12

RSC2 (RETURN SUB - Carrier #2-Third 50 KHz Carrier)

Multiframe		4k																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2																											
TR6		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
Multiframe		4k+1																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2																											
TR6		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
Multiframe		4k+2																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2																											
TR6		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
Multiframe		4k+3																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2																											
TR6		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	

FIG. 4.
(PRIOR ART)

WO 00/27053

PCT/US99/20731

5/12

RSC3 (RETURN SUB - Carrier #3-Fourth 50 KHz Carrier)

Multiframe		4k																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3		G									G																
TR7		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
Multiframe		4k+1																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3		G										G															G
TR7		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
Multiframe		4k+2																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3		G										G															G
TR7		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
Multiframe		4k+3																									
Frame		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3		G										G															G
TR7		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	

FIG. 5.
(PRIOR ART)

WO 00/27053

PCT/US99/20731

6/12

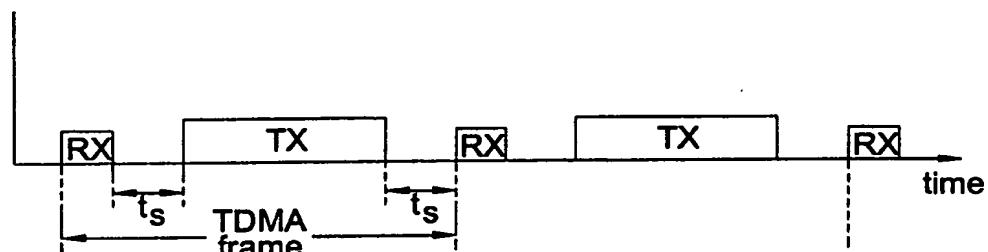
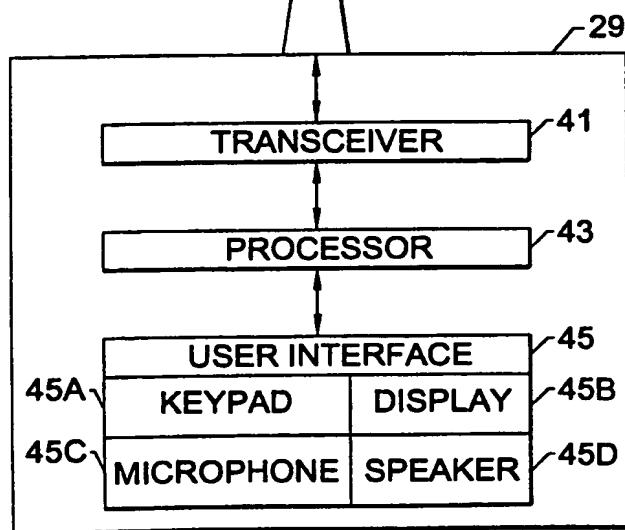


FIG. 6.
(PRIOR ART)

FIG. 8.



SUBSTITUTE SHEET (RULE 26)

WO 00/27053

PCT/US99/20731

7/12

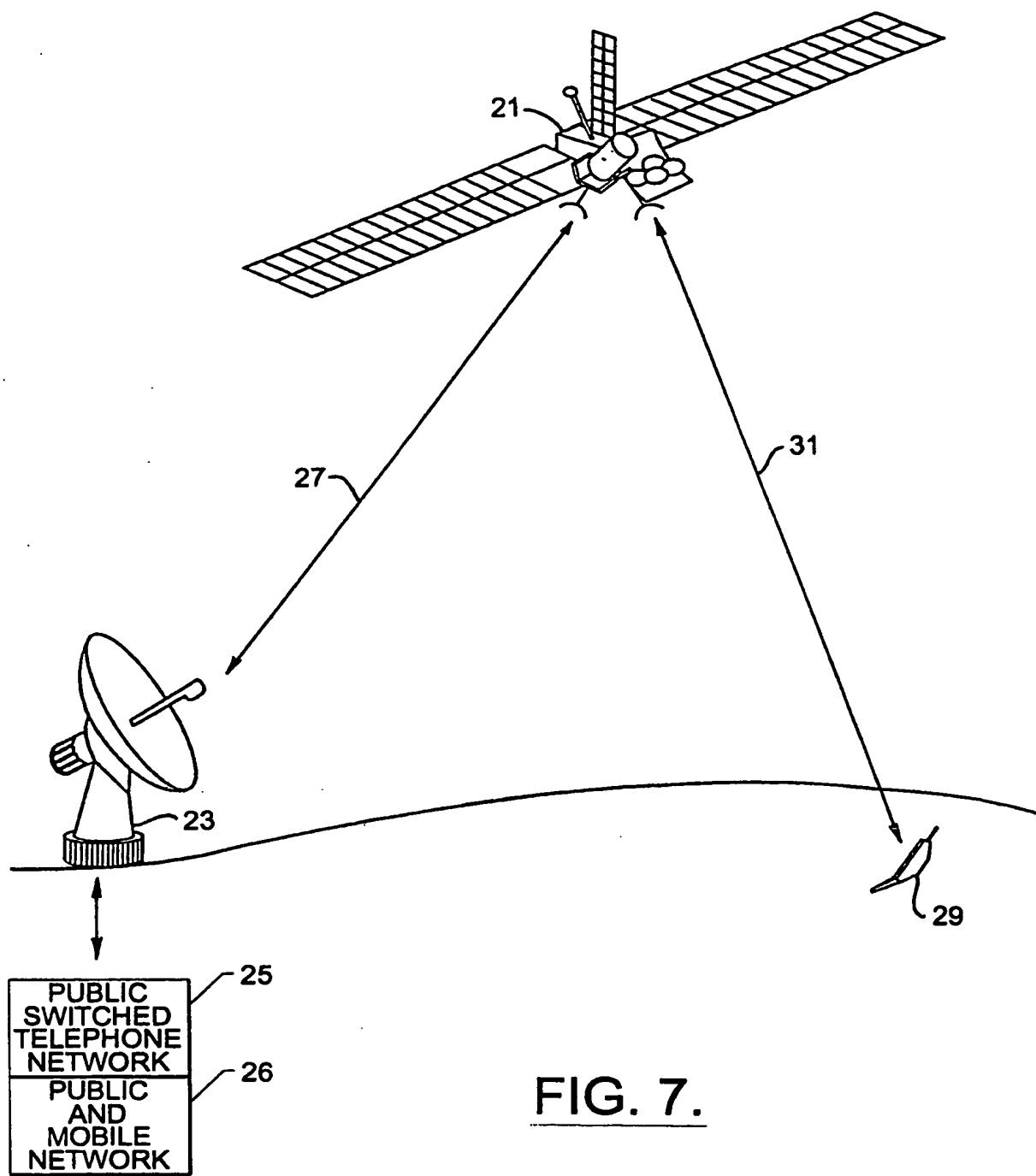


FIG. 7.

WO 00/27053

PCT/US99/20731

8/12

FC' (FORWARD CARRIER - 200 KHz Carrier)

Multiframe	4k																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF2'	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3'	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4'	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5'	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6'	G		G																							
TF7'			H																							
Multiframe	4k+1																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF2'	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3'	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4'	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5'	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6'	G		G																							
TF7'			H																							
Multiframe	4k+2																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF2'	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3'	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4'	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5'	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6'	G		G																							
TF7'			H																							
Multiframe	4k+3																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TF0'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TF2'	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
TF3'	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
TF4'	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
TF5'	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
TF6'	G		G																							
TF7'			H																							

FIG. 9.

SUBSTITUTE SHEET (RULE 26)

WO 00/27053

PCT/US99/20731

9/12

RSCO' (RETURN SUB - Carrier #0 First 50 KHz Carrier)

Multiframe		4k																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	
TR4'					H'										H'										H'	
Multiframe		4k+1																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0'	D'	D'	D'	D'	D'	D	D'																			
TR4'					H'										H'										H'	
Multiframe		4k+2																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	
TR4'					H'										H'										H'	
Multiframe		4k+3																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR0'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	D'	
TR4'					H'										H'										H'	H'

FIG. 10.

WO 00/27053

PCT/US99/20731

10/12

RSC1' (RETURN SUB - Carrier #1 Second 50 KHz Carrier)

Multiframe	4k																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TR5'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
Multiframe	4k+1																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	B'	
TR5'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	B'	
Multiframe	4k+2																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
TR5'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	
Multiframe	4k+3																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR1'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	B'	
TR5'	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	A'	B	B'	

FIG. 11.

WO 00/27053

PCT/US99/20731

11/12

RSC2' (RETURN SUB - Carrier #2-Third 50 KHz Carrier)

Multiframe		4k																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2'			F			F			F			F			F			F			F			F		
TR6'	E		E			E			E			E			E			E			E			E		
Multiframe		4k+1																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2'			F			F			F			F			F			F			F			F		
TR6'	E		E			E			E			E			E			E			E					
Multiframe		4k+2																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2'			F			F			F			F			F			F			F			F		
TR6'	E		E			E			E			E			E			E			E			E		
Multiframe		4k+3																								
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR2'			F			F			F			F			F			F			F			F		
TR6'	E		E			E			E			E			E			E			E					

FIG. 12.

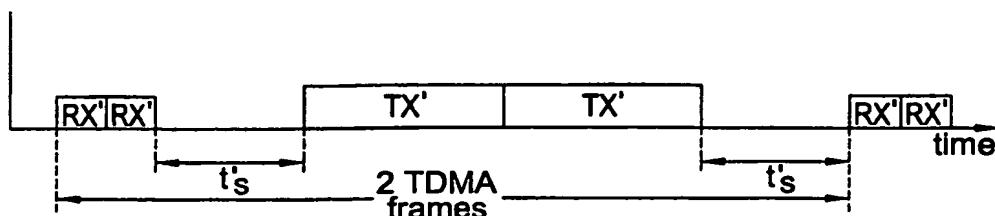
WO 00/27053

PCT/US99/20731

12/12

(RETURN SUB - Carrier #3-Fourth 50 KHz Carrier)

Multiframe	4k																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3'		G								G																
TR7'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	
Multiframe	4k+1																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3'		G								G																G'
TR7'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	
Multiframe	4k+2																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3'		G								G																
TR7'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	
Multiframe	4k+3																									
Frame	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TR3'		G								G																
TR7'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	C'	

FIG. 13.**FIG. 14.**

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/20731

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/26 H04B7/212

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 24194 A (NOKIA TELECOMMUNICATIONS OY ;JOKINEN HARRI (FI); POSTI HARRI (FI);) 4 June 1998 (1998-06-04)	1-3, 5, 6, 9, 23, 24, 26, 28, 29, 32
Y	abstract page 2, line 21-31 page 5, line 19 -page 6, line 8 page 7, line 2-7 figure 3 claims ---	12-14, 16, 17
Y	EP 0 536 864 A (NETWORK ACCESS CORP) 14 April 1993 (1993-04-14) column 15, line 20 -column 17, line 3 figure 12 ---	12-14, 16, 17
		-/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Date of the actual completion of the international search

21 December 1999

Date of mailing of the international search report

12/01/2000

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 38502 A (HASSAN AMER ;RAMESH RAJARAM (US); ERICSSON GE MOBILE INC (US); MAS) 16 October 1997 (1997-10-16) page 1, line 15 -page 4, line 14 figures 1-3 ---	25
A	WO 96 10892 A (MOTOROLA INC) 11 April 1996 (1996-04-11) page 5, line 25 -page 7, line 27 page 8, line 30 -page 9, line 36 page 17, line 14-29 page 27, line 15-28 figure 14 -----	1,12,23, 25

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/20731

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
WO 9824194	A 04-06-1998	FI 964731	A	28-05-1998	
		AU 5055998	A	22-06-1998	
		EP 0943188	A	22-09-1999	
		NO 992551	A	27-05-1999	
EP 0536864	A 14-04-1993	US 5233643	A	03-08-1993	
		CA 2080041	A	09-04-1993	
		JP 5268147	A	15-10-1993	
WO 9738502	A 16-10-1997	US 5796726	A	18-08-1998	
		AU 2439397	A	29-10-1997	
		CA 2247356	A	16-10-1997	
		CN 1215513	A	28-04-1999	
		EP 0893012	A	27-01-1999	
WO 9610892	A 11-04-1996	AU 3826495	A	26-04-1996	
		EP 0784906	A	23-07-1997	
		JP 10507046	T	07-07-1998	